CLAIMS

1. A method of performing maintenance on a sewer system that includes a main pipe and a plurality of lateral pipes communicating with the main pipe through lateral openings in the main pipe, the method comprising:

covering the walls of the main pipe with a liner that cuts off communication between the main and lateral pipes by covering the lateral openings;

detecting with a thermal sensor variations in the thermal conditions of the liner;

interpreting the variations in the thermal conditions to identify the portions of the liner that cover lateral openings; and

cutting through the portions of the liner that cover lateral openings to establish communication between the main and lateral pipes.

2. The method of claim 1, wherein the thermal sensor includes a thermal imaging camera and a screen displaying images from the thermal imaging camera; and wherein the detecting step includes using the thermal imaging camera and screen to view the thermal conditions of the liner.

3. The method of claim 2, wherein the cutting step includes viewing a cutting device through the thermal imaging camera and screen and using the images displayed on the screen to guide the cutting device to the portions of the liner covering lateral openings.

4. The method of claim 1, wherein the thermal sensor includes an infrared camera capable of detecting the temperature of a surface; and wherein the detecting step includes scanning the liner with the infrared camera to detect the thermal condition of the liner.

5. The method of claim 4, further comprising marking the location of a lateral opening that has been detected with the infrared camera; confirming with the infrared camera that the mark is appropriately positioned; and viewing the mark with a visual camera; wherein the cutting step includes using the visual camera to guide a cutting device to the marked portion of the liner and using the cutting device to cut the liner at the mark to open the lateral opening.

6. The method of claim 1, further comprising the steps of, prior to the detecting and interpreting steps, introducing water into the lateral pipes and retaining the water in the lateral pipes with the portions of the liner that cover the lateral openings.

7. The method of claim 1, further comprising the step of applying localized heat to the liner in an approximate position of a lateral opening prior to the detecting step.

8. The method of claim 7, further comprising the steps of, prior to the detecting and interpreting steps, introducing water into the lateral pipes and retaining the water in the lateral pipes with the portions of the liner that cover the lateral openings; wherein the detecting step includes monitoring the rate at which the applied localized heat dissipates from the liner; and wherein the interpreting step includes identifying as covering a lateral opening those areas of the liner that dissipate heat relatively quickly due to the water behind the liner.

9. The method of claim 7, wherein the applying localized heat step includes directing a source of light and heat toward the approximate position of a lateral opening.

10. The method of claim 1, wherein the main pipe includes an upstream end and a downstream end that is lower than the upstream end, such that water flowing out of the lateral pipes into the main pipe flows toward the downstream end of the main pipe; and wherein the cutting step includes establishing communication between the main and lateral pipes in an upstream progression.

11. The method of claim 10, wherein the cutting step includes using a cutting device to cut through the liner; and wherein the step of establishing communication between the main and lateral pipes in an upstream progression includes:

cutting the liner with the cutting device to open the lateral opening for a first lateral pipe to permit water to flow from the first lateral pipe into the main pipe;

using a visual camera to navigate the cutting device in the main pipe upstream of the water flowing out of the first lateral opening;

using the thermal sensor to execute the detecting and interpreting steps to identify a second lateral opening that is upstream of the first lateral opening; and

cutting the liner with the cutting device to open the second lateral opening.

12. A method of performing maintenance on a sewer pipe, the method comprising the steps of:

detecting with a thermal sensor variations in the thermal conditions of the sewer pipe;

interpreting the variations in the thermal conditions to determine where maintenance is needed; and

performing maintenance on the sewer pipe as determined in the interpreting step.

13. The method of claim 12, wherein the sewer pipe includes a main pipe and a plurality of lateral pipes communicating with the main pipe through lateral openings in the main pipe, wherein the walls of the main pipe are covered with a liner that cuts off communication between the main and lateral pipes by covering the lateral openings;

wherein the detecting step includes detecting with the thermal sensor variations in the thermal conditions of the liner;

wherein the interpreting step includes interpreting the variations in the thermal conditions to identify the portions of the liner that cover lateral openings; and

wherein the performing maintenance step includes cutting through the portions of the liner that cover lateral openings to establish communication between the main and lateral pipes.

14. The method of claim 12, further comprising installing a liner in the sewer pipe and applying heat to the liner such that the liner cures in place within the sewer pipe;

wherein the detecting step includes detecting with the thermal sensor variations in the temperature of the liner prior to the liner substantially curing;

wherein the interpreting step includes using the detected temperature information to determine whether the liner was properly heated prior to curing; and

wherein the performing maintenance step includes applying more heat to the liner if it is determined that portions of the liner were not properly heated.

15. The method of claim 12, further comprising installing a liner in the sewer pipe, the liner having an exothermic adhesive;

wherein the detecting step includes using the thermal sensor to identify the heat generated by the exothermic reaction;

wherein the interpreting step includes using the detected temperature information to determine whether the liner was properly installed in the sewer pipe; and

wherein the performing maintenance step includes repairing the liner if it is determined that the liner was improperly installed.

16. The method of claim 12, wherein the sewer pipe includes grout having an exothermic reaction;

wherein the detecting step includes using the thermal sensor to identify the location and condition of the grout based on the heat generated by the exothermic reaction;

wherein the interpreting step includes determining whether the grout was properly applied; and

wherein the performing maintenance step includes repairing the grout if it is determined that the grout was improperly applied.

17. The method of claim 12, wherein the detecting step includes detecting relatively cool portions of the pipe; wherein the interpreting step includes determining whether the relatively cool portions of the pipe are the source of groundwater leaks; and wherein the performing maintenance step includes patching any cracks in the sewer pipe at the source of the groundwater leaks.

18. An apparatus for performing maintenance on a sewer pipe, the apparatus comprising:

a thermal sensor;

means for moving the apparatus within the sewer pipe;

means for performing maintenance on the sewer pipe.

19. The apparatus of claim 18, further comprising a visual camera.

20. The apparatus of claim 19, wherein the visual camera and thermal sensor are contained within a single body having opposite ends, the visual camera being at one end of the body and the thermal sensor being at the opposite end of the body such that the visual camera and thermal sensor face away from each other.

21. The apparatus of claim 20, further comprising a pan and tilt motor supporting the body and capable of rotating the body to move one of the visual camera and thermal sensor into an active position for use by an operator and to move the other of the visual camera and thermal sensor into an inactive position.

22. The apparatus of claim 18, wherein the thermal sensor includes a thermal imaging camera capable of creating a visual display of the thermal condition of a surface.

23. The apparatus of claim 18, wherein the thermal sensor includes an infrared camera capable of detecting the temperature of a surface.

24. The apparatus of claim 23, wherein the sewer pipe includes at least one lateral pipe opening that is covered by a liner, wherein the infrared camera is capable of detecting the location of the covered lateral opening, wherein the means for performing maintenance includes a cutting device for cutting through the liner, the apparatus further comprising:

a visual camera; and

means for marking the location of the lateral opening such that the marked location is detectable by both the infrared camera and the visual camera;

wherein the infrared camera is operable to detect the section of liner that covers a lateral opening based on the temperature of the liner; and

wherein the visual camera is capable of monitoring the cutting device to accurately position the cutting device to cut through the portion of the liner covering the lateral opening.

25. The apparatus of claim 18, wherein the means for moving includes a propulsion motor mounted on the apparatus and a track drive system driven by the propulsion motor.

26. The apparatus of claim 18, wherein the sewer pipe includes a main pipe and at least one lateral pipe, wherein communication between the main and lateral pipes is cut off by a liner in the main pipe, and wherein the means for performing maintenance includes a cutting device for cutting the liner to establish communication between the main and lateral pipes.

27. The apparatus of claim 18, further comprising a pan and tilt motor for adjusting the orientation of the thermal sensor.

28. An apparatus for use in a sewer systems that include a main pipe, a plurality of lateral pipes, and a liner in the main pipe that covers lateral openings that would, but for the presence of the liner, place the main and lateral pipes in fluid communication with each other, the apparatus comprising:

a propulsion system for moving the apparatus within the sewer pipe;

a camera assembly including a body having opposite ends, a visual camera in one end of the body and a thermal sensor in the other end of the body;

a pan and tilt motor supporting the camera assembly and controlling the orientation of the camera assembly;

a cutting device having a cutting element; and

a remote control station above ground outside of the sewer system and enabling the remote control of the propulsion system, pan and tilt motor, and cutting device, and including a display for information from the visual camera and thermal sensor;

wherein the apparatus is remotely operable from the control station to detect with the camera assembly the covered lateral openings and to reinstate the lateral openings with the cutting device.

29. The apparatus of claim 28, wherein the thermal sensor includes a thermal imaging camera and wherein the display in the remote control station includes at least one video monitor for displaying images from the visual camera and thermal imaging camera.